eDof(Extend Depth of Field)

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1 INTRODUCTION

China represents the most fiercely competitive market for smartphones globally, with mobile photography being a critical feature(see Fig. 1). Since 2023, leading smartphone manufacturers have increasingly focused on telephoto photography capabilities. Despite continuous advancements in optical lenses and sensors, the limited depth of field often prevents the subject from being fully captured. Extend Depth of Field (eDof) technology addresses this issue by analyzing the sequence of images captured during continuous zoom of a smartphone lens, extracting the relatively clear regions from each frame, and then combining these regions based on their positions to form a new image with full depth of field.

Fig. 1. Promotional materials from smartphone companies like Xiaomi.

Figure 2 demonstrates the eDof technology I designed and developed, featured in the Xiaomi 14 Ultra, the highest-end flagship model released at the end of February this year. The native camera UI (at the top of the preview frame) allows consumers to switch to the "Depth Extension" mode with a tap. Once the user clicks the shutter button, it takes just 0.7 seconds to capture a sequence of seven 4K images at different focal points and synthesize a full-depth image.

Fig. 2. Camera interface of Xiaomi 14 Ultra demonstrating the eDof technology.

2 FRAMEWORK

Within a brief three-month period (August to November 2023), the entire pipeline was designed, programmed, tested, optimized, and launched from scratch. Due to commercial competition restrictions, Figure 3 only provides a rough overview of the eDof process. The entire eDof pipeline includes three main modules: an optical flow-based image registration model (0.45s), a monocular depth detection model (0.12s), and a clarity detection module (0.21s). The image registration training data uses the inference results of large models such as RAFT as ground truth for both unsupervised and supervised learning, while the monocular depth detection model uses the inference results of the Marigold model as partial ground truth.

Figure 4 illustrates the input frames and the final synthesized full-depth image of the eDof algorithm.

Figure 5 compares our eDof algorithm with Photoshop, showing that in over 1000 sets of images across more than 30 scenes, our algorithm significantly outperforms Photoshop in terms of clarity detection accuracy, edge transitions, and time performance (Photoshop often requires around 30 seconds for seven 4K images, excluding image import time).

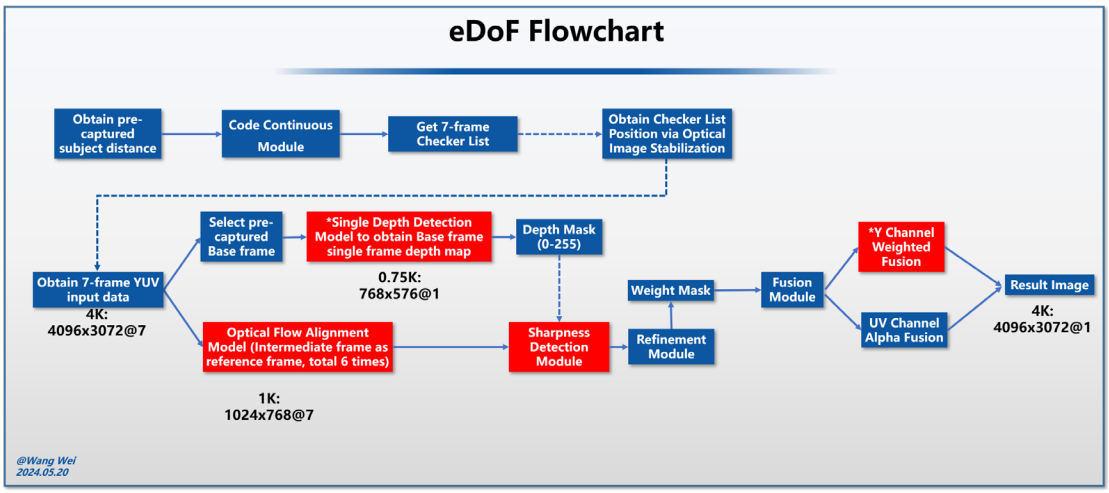


Fig. 3. Overview of the eDof scheme.

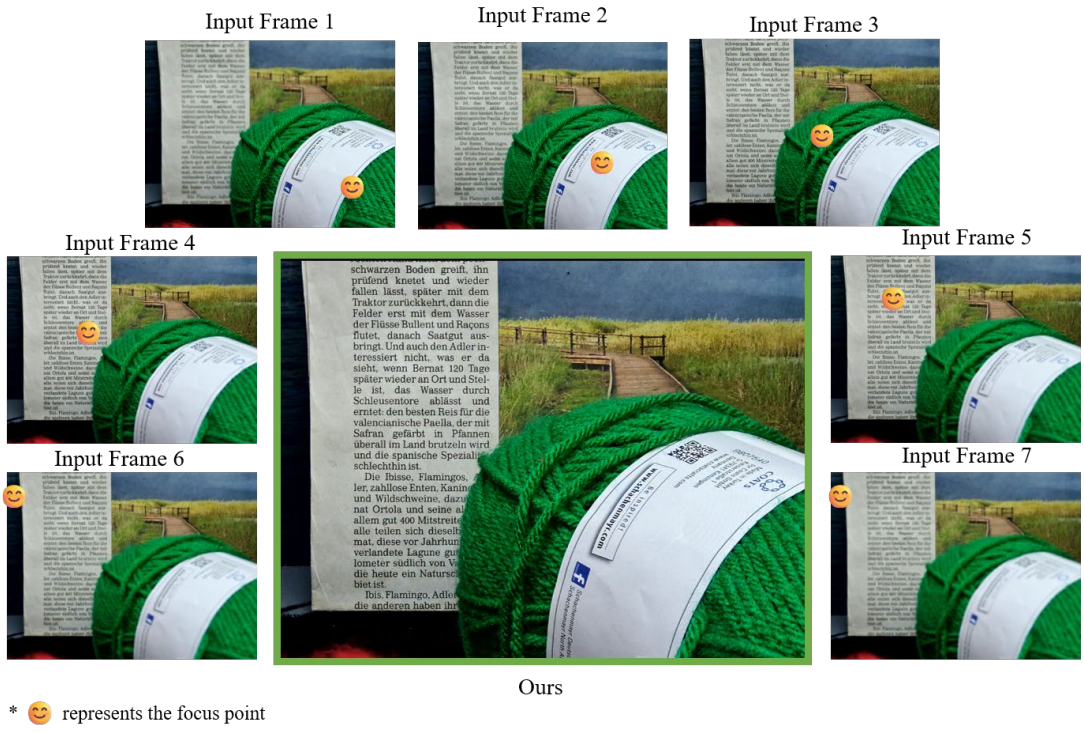


Fig. 4. Input frames and the synthesized full-depth image of the eDof algorithm.

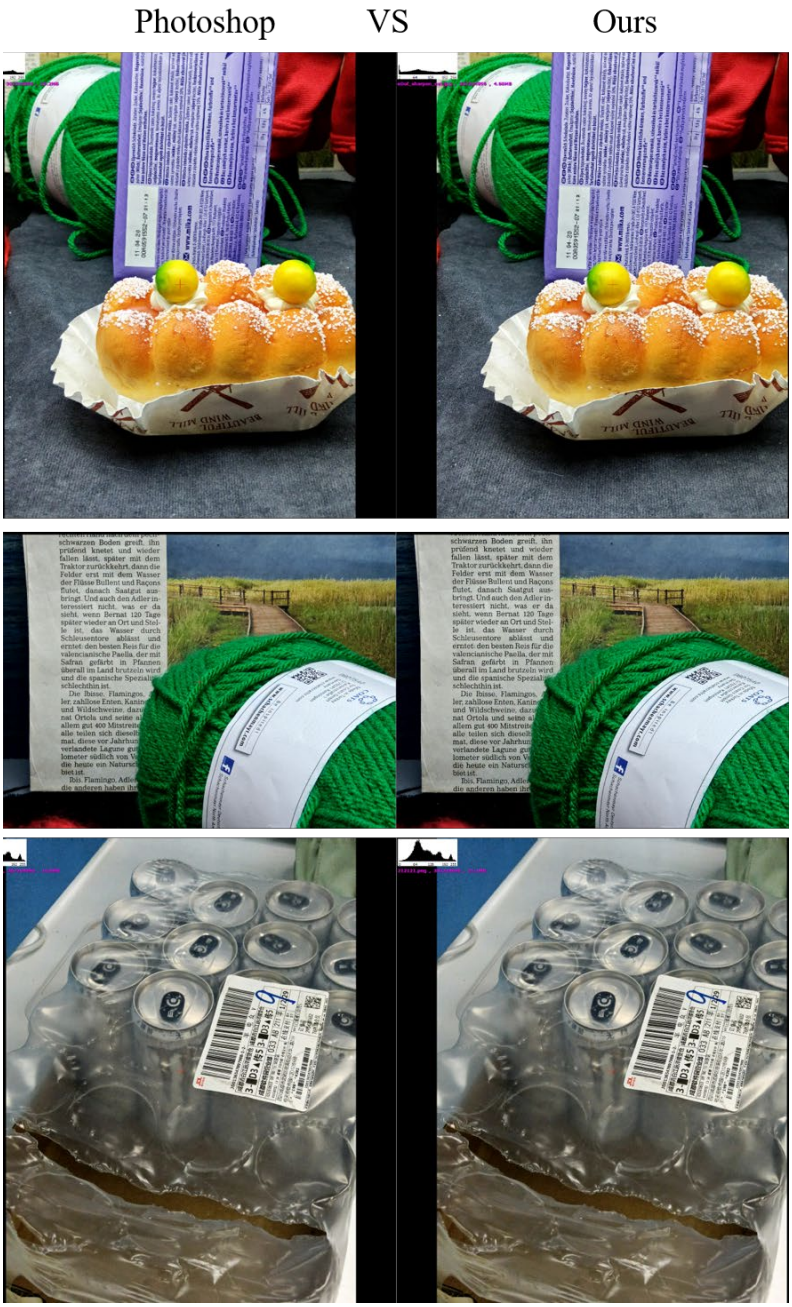
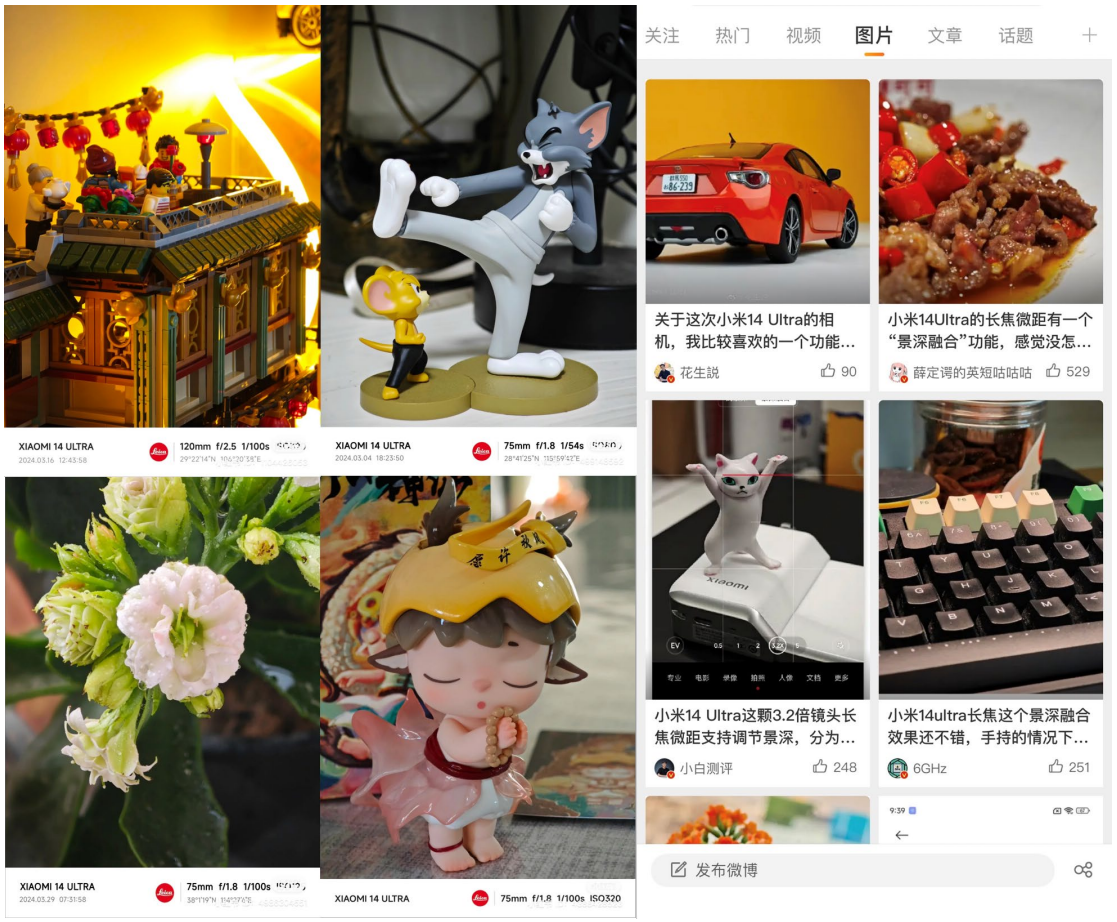


Fig. 5. Comparison between our eDof algorithm and Photoshop.

3 MEDIA REPORTS

With the release of the Xiaomi 14 Ultra, the eDof algorithm has received widespread acclaim on social media, as shown in Figure 6. I take great pride in seeing my algorithm being invoked repeatedly across millions of devices, bringing emotional resonance to consumers through imagery. This is a significant motivation and reason for my pursuit of a Ph.D.


XIAOMI 14 ULTRA
120mm f/2.5 1/100s
XIAOMI 14 ULTRA
75mm f/1.8 1/54s
XIAOMI 14 ULTRA
75mm f/1.8 1/100s
XIAOMI 14 ULTRA
75mm f/1.8 1/100s ISO320
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关于这次小米14 Ultra的相机，我比较喜欢的一个功能…
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90
小米14Ultra的长焦微距有一个“景深融合”功能，感觉没怎…
薛定谔的英短咕咕咕
529
小米14 Ultra这颗3.2倍镜头长焦微距支持调节景深，分为…
小白测评
248
小米14ultra长焦这个景深融合效果还不错，手持的情况下…
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景深融合
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75mm f/1.8 1/100s ISO64
XIAOMI 14 ULTRA
75mm f/1.8 1/100s ISO64
在相同的距离下实现景深扩展
外观做工
屏幕显示
61人正在看，已装填 4044 条弹幕
发个友善的弹幕见证当下
发送
2.0万
3484
2075
记笔记
弹幕列表

Fig. 6. Social media reviews of eDof in China, including platforms similar to Instagram, X, and YouTube.